REMARKS

The independent claims now proposed do not include the numerical limitations on flow velocities of the claims of the parent US Patent 6634412.

Attached is another copy of the article by Kenny, et al. on semi-solid metal casting already of record from the ASM Handbook. This is from the same volume as the article by Sully which has comprised the main citation to date. Kenny, et al. is not material to patentability in the negative sense in which Sully has been used. Instead, it negates the approach adopted by the Examiner in the parent application and, therefore, attention is directed to it again.

A first point of relevance arises from Figure 1 of Kenny, et al. Alloys can have a quite wide melting range between fully solid and fully liquid. This is particularly so for magnesium alloys for which the range can be up to 100°C between the start and completion of melting on heating, or the start and completion of solidification on cooling. This is due to different phases in the alloy having different compositions and, hence melting at different temperatures.

In both (a) and (b) of Figure 1 of Kenny, et al., the lighter coloured phase is higher melting point primary phase, while the darker background is lower melting point secondary phase. The primary phase in an alloy is the first to form during cooling of fully molten alloy. With progressive cooling, the primary phase grows in the melt in a normal casting in a dendritic structure (i.e. in a branched structure). This builds up a three dimensional skeletal structure, with individual crystals growing until they interfere with their neighbours. In an aluminium alloy, the primary phase is higher in aluminium than the secondary phase. As the dendritic primary phase grows with progressive cooling, the aluminium content of remaining

liquid is progressively lowered until it reaches the secondary phase composition and a temperature at which the secondary phase solidifies.

With conventional casting, the structure of Figure 1(a) is obtained. This has a three dimensional grid structure of primary phase, with gaps between branches filled by a matrix of secondary phase. In contrast, a microstructure of a casting produced from semi-solid alloy is shown in Figure 1 (b). In a semi-solid alloy, the melt is stirred while cooling to break up the forming dendrites to give discrete, rounded grains of what is referred to as a degenerate dendritic structure. The dendritic grains grow, but do not develop arms which interlock with adjacent grains.

If the casting of Figure 1(a) is heated, to melt only the secondary phase, the casting still has a solid form due to the interlocked primary phase structure which results in the casting still having substantial strength. Until the primary phase starts to melt on further heating, the casting still essentially is a solid. If the casting of Figure 1(b) is heated to melt the secondary phase, the casting still has some integrity. However, it is somewhat thixotropic and will flow under stress. Thus, as shown in Figure 2 of Kenny, et al., it is able to be manually cut by a spatula. This is due to the casting comprising discrete, rounded grains of primary phase freely floating in a liquid secondary phase.

Kenny, et al., in '103 propose a casting material a bit similar to semi-solid alloy, but in fact comprising alloy having particulate solid such as sand dispersed therein. Young in '241 prepares a part by mechanically subjecting a cooling melt to a shear rate related to the cooling rate to give a solid alloy as in Figure 1(b) of Kenny, et al., and then heating the alloy to the condition shown in Figure 2 of Kenny, et al., and shaping the reheated alloy. In Young '042, that shaping of reheated alloy is disclosed as being by deforming an ingot (in the

condition shown in Figure 2 of Kenny, et al.) into a die cavity, in a manner similar to extrusion forming of a solid ingot. Young is a co-inventor with Kenny in Kenny, et al. '103.

The art is characterised by (a) preforming a semi-solid alloy (i.e. melting, cooling under shear until solid, and then reheating), a process that takes considerable time, and then (b) shaping it such as by pressing it into a die cavity. This is confirmed by the attached paper by Modigell, et al. – see the first paragraph under the heading "Fundamentals" at page 16, and the description under the heading "Thixoforming" over pages 17 to 19.

All of this is intended to assist understanding of the invention. There has not previously been sufficient appreciation that, in the course of injecting molten magnesium alloy from a supply into a die cavity of a pressure casting machine, the alloy in the course of a casting cycle (i.e. within a period of less than a second) could be changed during its flow from the source to the cavity from a molten state to a semi-solid state. If this were not the case, persons skilled in the art would not seek to achieve the shaping of semi-solid material by first melting an alloy, then solidifying it by cooling while subjecting it to shear and then reheating to the semi-solid form for a shaping operation. That is, they would not take all this trouble if all they had to do was control flow velocities in the manner and as required by the claimed invention.

The rejection from the cited Bradley, et al. patent is traversed because it only discloses injection molding of metal alloy in a thixotropic, semi-solid state. The teaching is in the use of an injection molding technique used for plastics. In this, alloy in the form of pellets, chips or powder is fed at room temperature into a hopper and advanced by an extruder screw towards a nozzle leading to a mold. A barrel containing the screw is heated so that the alloy is partly melted to a semi-solid state in which it is injected into the mold. At no stage in the process of Bradley et al is there molten alloy which is caused to become semi-solid, and there is no teaching as to how this could be achieved.

The rejection from the cited Laxmanan patent is traversed because it only teaches placing a thixotropic block or billet in a ram, and extruding the block or billet into a mould, but not the semi-solid state claimed

Reconsideration and allowance are, therefore, requested.

Respectfully submitted,

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